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Thermophysical Properties of Sodium Acetate Trihydrate Composites as Heat Storage Material

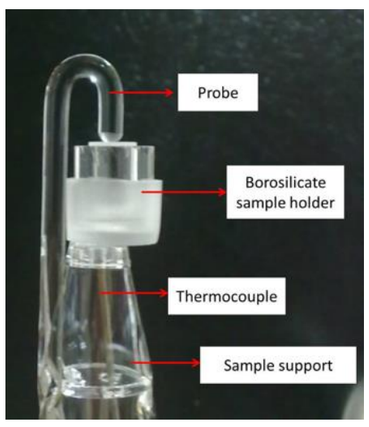
Mark Dannemand[1,2], Ana Lázaro[2], Mónica Delgado[2], Conchita Peñalosa[2], Carsten Gundlach[3], Camilla Trinderup[4], Jakob Berg Johansen[1], Janne Dragsted[1], Gerald Englmair[1], Weiqiang Kong[1], Simon Furbo[1]

[1]DTU Civil Engineering, Technical University of Denmark, Denmark
[3]DTU Physics, Technical University of Denmark, Denmark, [4]DTU Compute, Technical University of Denmark, Denmark
[2]Aragón Institute for Engineering Research (I3A), Thermal Engineering and Energy Systems Group, University of Zaragoza, Spain
markd@byg.dtu.dk

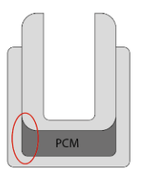
Introduction: Sodium acetate trihydrate (SAT) can be used as a phase change material (PCM) in heat storage applications. The melting point at 58 °C and favorable thermophysical properties makes it a suitable storage material in solar heating systems applications for space heating and domestic hot water preparation. Additives are used to stabilize the PCM, optimize or enhance the material properties and ensure cycling stability.

SAT can be used for long term heat storage by utilizing its ability to supercool stable to ambient temperature or for short term heat storage where the supercooling is avoided. Material investigations were carried out considering the behavior of SAT with and without supercooling.

Density - porosity: The density and thermal expansion of SAT in liquid and solid state was measured. The characteristics of the cavities formed inside of solidified SAT were found by x-ray scanning. The measured density of SAT solidified from a supercooled state was less than the typical literature value. The X-ray scanning confirmed that 15% of the volume of a sample which had solidified from supercooled state was cavities.

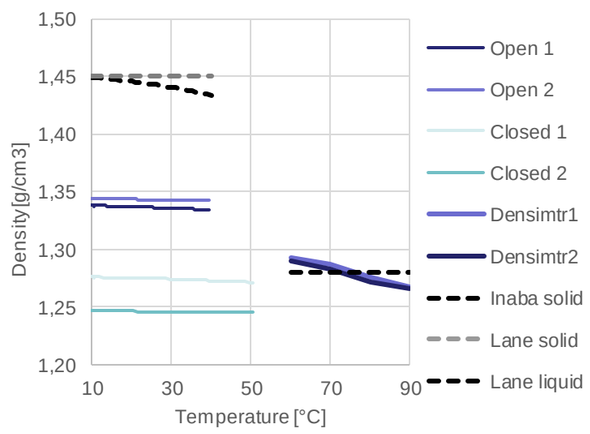


Thermo mechanical analyzer (TMA)

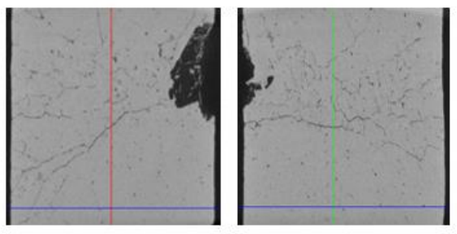
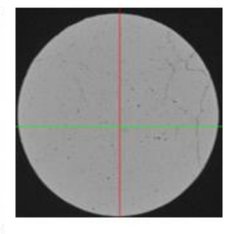


Closed sample holder


Open sample holder

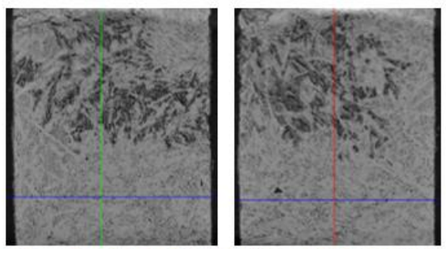


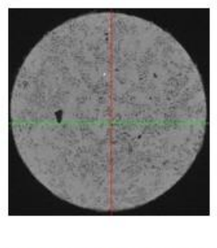
Density measurements vs. literature


X-rayed samples: Ø 10 mm, h = 10 mm

X, Y and Z cut planes and 3D illustration of SAT solidified without supercooling

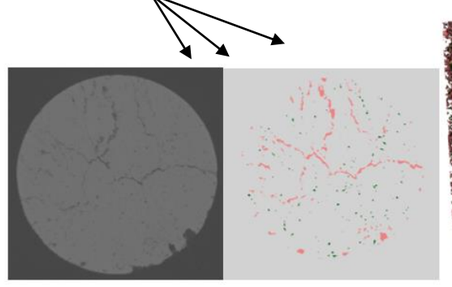


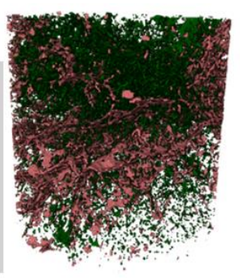


Green = closed cavities

Red = connected cavities

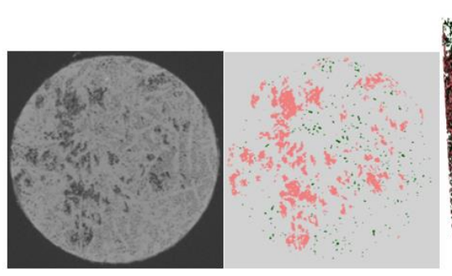
X, Y and Z cut planes and 3D illustration of SAT solidified from supercooled state

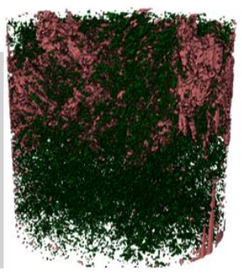



Slice and corresponding segmentation and 3D illustration of SAT solidified without supercooling

Sample	Cavity/ total volume	Enclosed cavity/ total cavity
Solid SAT (non-supercooled)	0.07	0.13
Solid SAT (supercooled)	0.15	0.09

Cavities in SAT samples

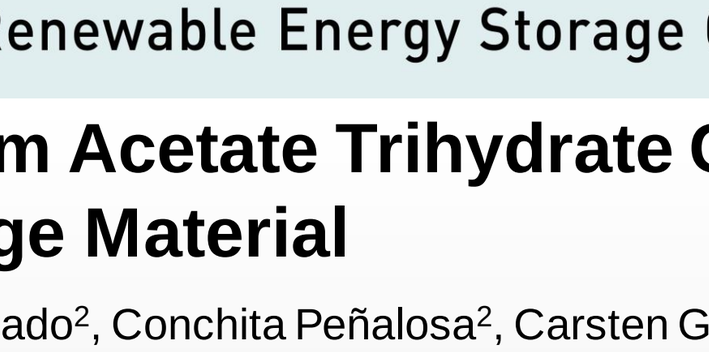



Slice and corresponding segmentation and 3D illustration of SAT solidified from supercooled state

Sample	Density g/cm³
Solid SAT (non-supercooled)	$\rho_{s(non-supercool)} = -7.8 \cdot 10^{-5} \cdot T + 1.3423$ For 10 °C < T < 40 °C
Solid SAT (supercooled)	$\rho_{s(supercool)} = -7.6 \cdot 10^{-5} \cdot T + 1.2622$ For 10 °C < T < 50 °C.
Liquid SAT	$\rho_{l} = -8.63 \cdot 10^{-4} \cdot T + 1.3438$ For 60 °C < T < 90 °C.

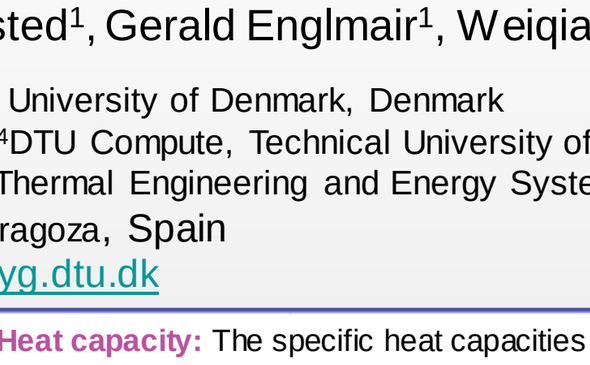
Expressions for solid and liquid density

Heat capacity: The specific heat capacities and latent heat of fusions of SAT composites were measured by differential scanning calorimetry **(DSC)** and the **T-history** method. The measurements showed that the additives had little effect on the specific heat capacities of the SAT composites. SAT composites with CMC or Xanthan rubber was investigated.



Literature values for specific heat of solid and liquid SAT

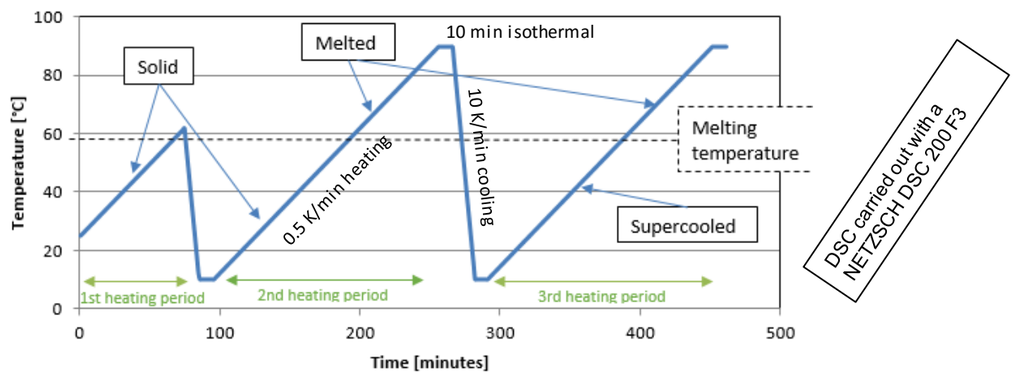

Test tubes with water and SAT composite with needle through septum in screw cap



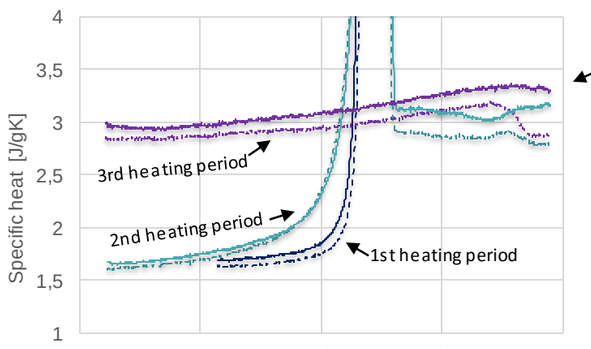
T-history measurements

Sample	Latent heat of fusion [kJ/kg]
SAT (litterature)	265
SAT – CMC	218
SAT – Xanthan	225

Latent heat of fusion values from T-history



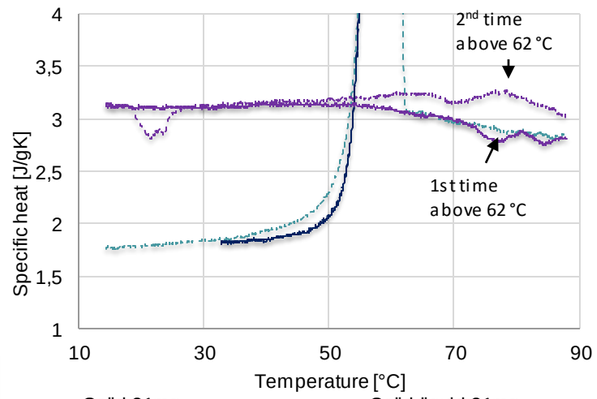
Temperature ramp for DSC.



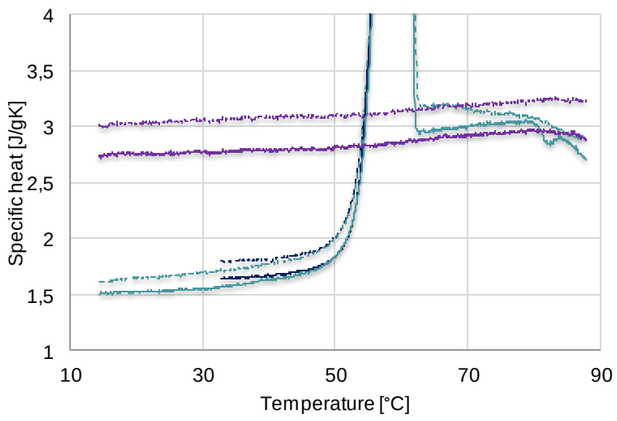
Specific enthalpy for SAT without additives measured with DSC.

Significant difference in measured solid c_p for 1st and 2nd heating period

20 mg SAT – CMC sample did not solidify during 1st cooing period



Specific enthalpy for SAT with 1% CMC measured with DSC.



Specific enthalpy for SAT with 0.5 % Xanthan rubber measured with DSC.

Characteristic drop in measured liquid c_p at around 80 °C

SAT composite with xanthan rubber (X) and xanthan rubber and 10% graphite powder (XC)

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